




**THE DEMAND FOR GAMING IN AUSTRALIA:
AN APPLICATION OF QUAIDS**

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I certify that this dissertation is entirely my own original work, contains no material that has otherwise been submitted for assessment or publication by myself and incorporates no copy or paraphrase of any material previously published by any person or persons except where due acknowledgment has been made.



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Abstract

A theoretical model is developed, which resolves the conflict between observed gaming behaviour and Neoclassical rational agent theory. This model provides testable hypotheses regarding the participation in various types of gaming activities and the welfare effects of taxation on gaming.

The demographic and socio-economic determinants of demand for gaming in Australia are measured using the parametric QUAIDS model. Based on the econometric results, the regressivity of gaming taxes is calculated using income elasticities of the budget share of gaming expenditures.

Results obtained provide strong support for the theoretical model, and provide evidence to support the position that reliance upon gaming taxation receipts by Australian State Governments may lead to an increasingly regressive State based taxation system.

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Chapter 1

1.1 Introduction

1.1.1 Definition of Gambling and Statement of the Problem

Gambling has been defined as “...*the wager of any type of item or possession of value upon a game or event of uncertain outcome in which change, of variable degree, determine such outcome*¹”.

Economics has traditionally devoted little attention to issues involving gambling due to the difficulty in reconciling the “rational economic agent” and “risk-averse behaviour” used in expected utility analysis with the actual practice of gambling. The literature has developed in two main directions in order to reconcile observed behaviour with economic theory. The participant must either be risk-loving over some section of the utility function or attain intrinsic utility from the activity.

A theoretical model is developed which illustrates that rational economic agents may incorporate both gambling and risk-averse behaviour such as insuring, particularly over some sections of the associated utility function. This theoretical model allows inferences to be drawn with respect to what factors influence people to gamble, and, in turn, where the implicit burden of taxation may lie. These inferences are tested empirically, leading to the formation of the policy implications of gambling.

¹ Bolen and Boyd, 1968 as cited in *Survey of American Gambling Habits*, 1977.

1.1.2 The Rise of Gambling in Australia

In 1996 Australia had the second highest per capita expenditure on gambling of any nation, behind only the USA.² This expansion of the domestic gambling industry has allowed State governments in Australia to rely relatively more heavily on gambling revenue when compared to governments in similar economies.³ The 1997 decision of the High Court of Australia to disallow State governments to continue to levy excise taxes on petroleum, tobacco and alcohol products implies that this reliance on gambling revenue to fill State Treasury coffers will continue to grow.

The previous decade has seen a significant expansion in State supported gambling activity in all States, with casinos opening in Western Australia, South Australia, Queensland, New South Wales, the Australian Capital Territory and Victoria, as well the continuing expansion of Tasmania's Wrest Point which opened in 1973 and the Northern Territory casino. In addition, there has been a notable increase in the number of poker machines available. State governments, "sensing this relatively electorally painless way of raising revenue"⁴, have increased collections of gambling-related revenues. An example of the effect this has had on State revenues is that in 1996, the \$400 billion Crown Casino complex in Melbourne delivered \$1.2 million daily to the State government in gambling revenue alone. Gambling revenue in Victoria in 1995/96 contributed 12.5% of State own-source revenue, while in Queensland in the same period the figure was 14.6%.⁵

² Sixty Minutes, 27/09/97. The real net per capita gaming expenditure for Australians in 1995-96 was \$581.21.

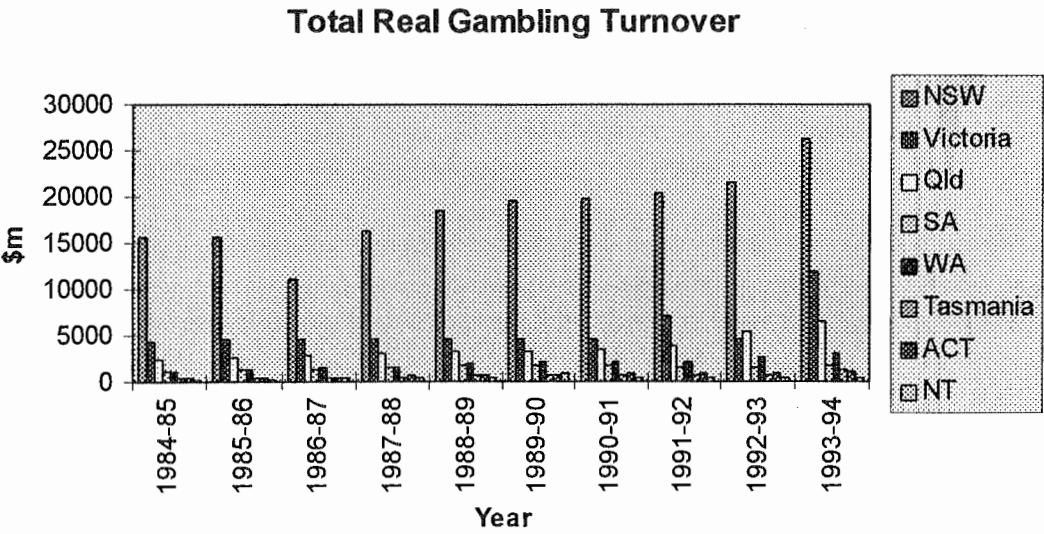
³ Worthington, 1997.

⁴ Kitchen and Powells, 1991.

⁵ Worthington, 1997.

The growth of gambling activity in Australia can be illustrated with reference to annual aggregate figures published by the Tasmanian Gaming Commission and the Centre for Regional Economic Analysis (CREA) at the University of Tasmania. Figure 1 presents a State by State comparison of gambling activity⁶ which illustrates the 300.93% increase in gambling turnover in the period.

Figure 1.1 - State Comparison of Gambling Turnover



In addition it is worth noting that while gaming has remained a popular recreation activity in Australia the number of persons participating in gaming activity has fallen from 61.15% in 1984-85 to 55.97% in 1993-94.⁷ This indicates that the increase in aggregate gaming turnover results largely from regular participants increasing their expenditure on gaming rather than an increase in the number of new participants.

⁶ The period 1984-85 to 1993-94 was chosen to coincide with the period of the Household Expenditure Survey data which will be used for estimation purposes. Figures are in 1995-96 \$A. More detail on this is given in Chapter 3..

⁷ From the HES data. Measured as a percentage of those with some form of gaming expenditure as defined in the survey from the sample size. See Appendix 1 for details of participation in gaming.

1.2 Rationale for Investigation

The expanded reliance on gambling revenues by State governments raises questions as to the welfare implications of gambling taxes. This leads to two questions for economists: firstly, what are the determinants of the demand for gambling, and second, what is the incidence of the economic burden of the implicit gambling taxes. As early as Pryor (1976), the issue of the regressivity of gambling taxes has been examined. Pryor found a significant positive relationship between “classical gambling”⁸ in various societies and the general socio-economic inequality in those societies.

The majority of gambling-related economic literature has been conducted in the United States and Canada, and has focused on the regressivity of racing expenditure and State lottery ticket sales. A notable study by Borg, Mason and Shapiro (1991)⁹ is the only major study to determine demographically the demand for casino games and assess the incidence of casino taxes in Las Vegas and Atlantic City.¹⁰ Using a similar approach, Scott and Garen (1994) analysed the determinants of demand and incidence of taxation for the Kentucky State lottery.

Reliance on gambling revenue by State governments has been criticised in the United States by Madhadhusan¹¹, Suits¹², Calmus¹³ and Stocker¹⁴ amongst others and in Canada

⁸ ‘Classical gambling’ refers to traditional gambling activities such as wagering on horses, card games etc. This excludes lotto style gambling and such modern innovations as poker machines. Due to the increased accessibility of gambling products to lower socio-economic groups, such a relationship may be negative for some products in Australia.

⁹ The Incidence of Taxes on Casino Gambling: Exploiting the Tired and Poor.

¹⁰ Regressivity in Australia may be more pronounced due to lower cost of access to casinos.

¹¹ Madhadhusan, R., 1996.

¹² Suits, D., 1977.

¹³ Calmus, T., 1981.

by Henriksson¹⁵. The focus of this criticism has been the influence of other economic factors on gambling revenue as well as the potential regressivity of gambling taxes, (see Suits 1977). This criticism does not appear to have dissuaded either Australian State governments or US and Canadian governments from following the trend¹⁶ of attempting to establish a solid revenue base from gambling.

A point of contention in gambling theory is whether or not the sale of gambling products should be considered as implicit taxation, because the purchase of gambling products is voluntary. Kitchen and Powells (1991) argue that consumption of such products is “no different from the consumption of alcohol, tobacco or any other taxed product. Indeed, the implicit [gambling] tax is exactly analogous to an excise tax on any commodity”.¹⁷ A welfare implication of the consumption of gambling products is that the implicit taxation may be fundamentally regressive, “that is, the tax paid by households as a percentage of income is higher for low income households than high income households”.¹⁸ Kitchen and Powells (1991) are supported by Borg, Mason and Shapiro (1993):

*“...taxes on gambling are taxes even though gambling is a voluntary activity. Specifically, they are excise taxes in the same way that assessments on liquor and cigarettes (two other voluntary purchases) are taxes. As a result, it is valid to consider whether the burden imposed by taxes on gambling is distributed in an equitable manner.”*¹⁹

¹⁴ Stocker, F., 1972

¹⁵ Henriksson, L., *Hardly a Quick Fix*, Canadian Public Policy, 22(2) June 1996, 166-28.

¹⁶ What Madhadhusan and Henriksson term “Casino Fever”.

¹⁷ Clotfelter and Cook (1989), Ch.11.

¹⁸ Kitchen and Powells (1991), pg 1849.

¹⁹ p 323.

This proposition is supported by empirical evidence that gambling is more prevalent in lower socio-economic households²⁰, thus making a tax on gambling regressive.

This evidence is more strongly supportive of the hypothesis that gaming as opposed to other forms of gambling²¹ is regressive:

*“On the basis of the sample who have given themselves access to casino gambling, the tax is regressive; in fact it is extremely regressive in Las Vegas. Therefore, in this time of easier access to casino gambling, policy-makers should be aware that the taxes on casino gambling place a proportionately heavier burden on low income groups.”*²²

The accessibility of gambling facilities is cited in Borg et al (1993) as a major factor influencing the difference in the comparative regressivity of gambling taxes in Las Vegas, Nevada and Atlantic City, New Jersey. The results from this study show that the incidence of taxation from the relatively more accessible gambling facilities of Atlantic City²³ is more regressive than the incidence of gambling taxes in Nevada. The implication to be drawn from this study is that the implicit tax burden has the potential to be more regressive as gambling facilities become more accessible. This is particularly relevant in Australia, where the expansion of gambling facilities in all major cities has made access to such activities easier than in any comparative economy and at any other period. By supporting the expansion of gambling facilities, State

²⁰ See, for example, *Sixty Minutes*, 27/09/97 and *Bulletin Magazine*, 30 July, 1996, and 19 December, 1995.

²¹ Section 1.3 defines this distinction.

²² *Ibid*, p 323.

²³ The article cites that at the time of publication twenty-two million people, or 11% of the US population lived within a two-hour drive of Atlantic City, whereas most non-resident gamblers fly to Las Vegas.

governments may be creating a more regressive tax system, particularly with the observed increases in gambling turnover in each State.

The aim of this paper is to extend the content and quality of the available economic literature concerning gambling activity in Australian economic research, which at this point is currently one study: Worthington 1997. The goal is to identify the determinants of demand for gaming in Australia and measure the regressivity of gaming taxes.

1.3 The Distinction Between Gambling and Gaming

Gaming expenditure is defined as expenditure on “all legal forms of gambling other than racing, such as lotteries, poker and gambling machines, casino gaming, football pools and minor gaming (which is the collective name given to raffles, bingo, lucky envelopes and the like)”²⁴. Gambling expenditure is defined as expenditure on gaming plus all racing expenditure, which “comprises legal betting with bookmakers and totalisators, both on and off-course (TAB). It is related to betting on the outcome of horse and greyhound races, and, in recent times, on some other specified sporting events, such as football matches”.²⁵

²⁴ Tasmanian Gaming Commission and CREA, *Australian Gambling Statistics 1972-73 to 1995-96*, pg. 2.

²⁵ Ibid, pg. 3.

In this paper a clear distinction will be made between gambling and gaming, as defined by the Australian Bureau of Statistics²⁶, for two reasons. First, there is significant anecdotal evidence²⁷ to suggest that racing wagering is more the province of 'high-rollers'; that is, there is a notable socio-economic difference between participants in racing wagering and gaming activity, with the racing industry enjoying support from those in a more financially secure position. The second reason is that in all gaming activities, the price of the game, the 'takeout', is fixed, as are the associated probabilities of a successful outcome for any wager. Racing expenditure is also pari-mutuel in nature, meaning that the relative expenditure on each prospect (eg. horse) in each trial (race) determines the pay-off for a successful wager. Further the probability of being successful on any wager is not constant, but is also a function of human knowledge and expertise. That is, knowledge may improve the probability of success.

Finally, it is worth noting an empirical justification for this distinction. Racing turnover has been virtually static over the past decade 1984-85 to 1993-94, while gaming turnover has increased dramatically, as is illustrated by the tables in Appendix 1.

The focus of the analysis is on estimation of determinants of gaming expenditure within a fully specified demand system. The aim is to identify the significant demographic determinants of demand for gaming in Australia and to measure the potential regressivity of gaming taxes.

²⁶ Gaming is defined as "all legal forms of gambling other than racing, such as lotteries, poker and gambling machines, casino gaming, football pools and minor gaming (which is the collective name given to raffles, bingo, lucky envelopes and the like)".

²⁷ See, for example, *Sixty Minutes*, 27/09/97 and *Bulletin Magazine*, 30 July, 1996, and 19 December, 1995.

1.4 Plan of Dissertation

Chapter 2 presents a review of the existing theoretical literature on the utility for gambling with an emphasis on the directly conferred utility of gambling, establishing an approach whereby the observed behaviour of economic agents who both gamble and insure may be studied within the Neoclassical expected utility maximisation framework. Chapter 3 discusses the relevant data and estimation issues. Results of the estimation process and the measures of the regressivity of gaming taxes are presented in Chapter 4. A summary of the results and policy implications of the estimation, and areas for further research are presented in Chapter 5.

Chapter 2

2.1 The Utility of Gambling

There is a comparatively small amount of economic literature devoted to the analysis of gambling, due in part, to the difficulty in reconciling the activity of gambling with standard economic analysis. “It is hard to explain why individuals simultaneously pay to decrease risk [insurance] and pay to increase risk [gambling]”¹. The differing behaviour evidenced by economic agents who both gamble and insure is a puzzle for economists attempting to explain the incidence of gambling within the neoclassical framework of expected utility maximisation of rational agents. The standard methodology is to treat gamblers as having the sole motive of improving their wealth position,² the intrinsic utility to be gained from gambling as a recreation activity “is well recognised, but almost always resisted”³.

Samuelson (1952) commented that “a large fraction of the sociology of gambling and risk-taking will never be significantly discernible in terms of money prizes alone, as distinct from elements of suspense and gamesmanship”⁴. This view was again voiced by Becker after the 1977 *Survey of American Gambling Attitudes and Behaviour* “...the activity of gambling rather than the implications for wealth, is the primary motive for most forms of gambling; and gambling takes place despite substantially unfair odds”⁵.

¹ Conlisk (1993).

² Since, due to low probabilities of winning, all gamblers will be losers in the long run, this approach would seem to be flawed, particularly if the neoclassical assumptions of perfect information and rationality apply.

³ Ibid (1993).

⁴ Samuelson 1962 p 677.

⁵ Becker (1979).

This is especially true for gaming, where in repeated plays, the gambler is certain to lose, but less so for wagering, where through the use of knowledge, certain betting techniques and human error there is scope to win in the long run.

It is somewhat surprising to find that in the interim period between Samuelson and the present, economics has developed two fundamentally different models to explain gambling behaviour, but neither includes any utility of gambling itself. The utility functions are defined only in terms of the expected payoffs and the probabilities of winning.

The following sections outline the two traditional models of gambling behaviour, and then a new approach which incorporates an intrinsic, or directly conferred, utility of gambling as suggested but not incorporated by Becker (1977), Arrow (1974), Hirschleifer (1966) and Markowitz (1952). The Conlisk (1993) model of intrinsic utility provides a rationale for risk-averse and risk-loving behaviour to exist simultaneously while maintaining the neoclassical expected utility framework.

This approach is supported by Daniel Suits, a leading US economist in this field, who argues in favour of gambling directly conferring utility:

“Gambler’s are perfectly aware that they will lose on the average, but they view this expectation of loss as the price paid to engage in the game. For most gamblers, in other words, the purpose of gambling is not to get rich, but to ‘have fun’, to experience ‘excitement’, or to have ‘something to look forward to’, and they view payment for this recreation in the same light as

*others look on outlays for theatre tickets, vacation trips, or a night on the town.”*⁶

2.2 Traditional Models of the Utility of Gambling

2.2.1 The Psychological Model

The first of the two traditional models is the psychological model, where gambling is viewed as an enjoyable pastime, participation in which imbues the gambler with personal and social gratification like other recreation activities, but the actual participation is modelled on the gambler systematically misperceiving the probabilities involved in risky prospects.⁷ Brunk (1981) cites, amongst others, psychological studies by Preston and Booth (1948), Fellner (1965) and Yaari (1965), and argues that the “...long history of psychological research investigating individual behaviour under conditions of risk [as explained above] should be a generally accepted psychological law”⁸. Weitzman (1965) and Ali (1977) provide empirical support for the contention that individuals systematically overestimate beneficial but low probability outcomes (winning) and underestimate chance of detrimental outcome (losing) as investigated by Brunk (1981).

⁶ Suits (1979).

⁷ The misperception of the odds is what stimulates the actual participation. According to the theory, even though the activity provides utility, rational agents will not participate due to the fact that in the long run gamblers will worsen their wealth position. Only if the probability of success is favourably misperceived will a gamble be accepted.

⁸ Brunk (1981) and see for supporting evidence using wagering on horse racing, Ali (1977), Weitzman (1965), McGlothlin (1956) and Griffith (1949).

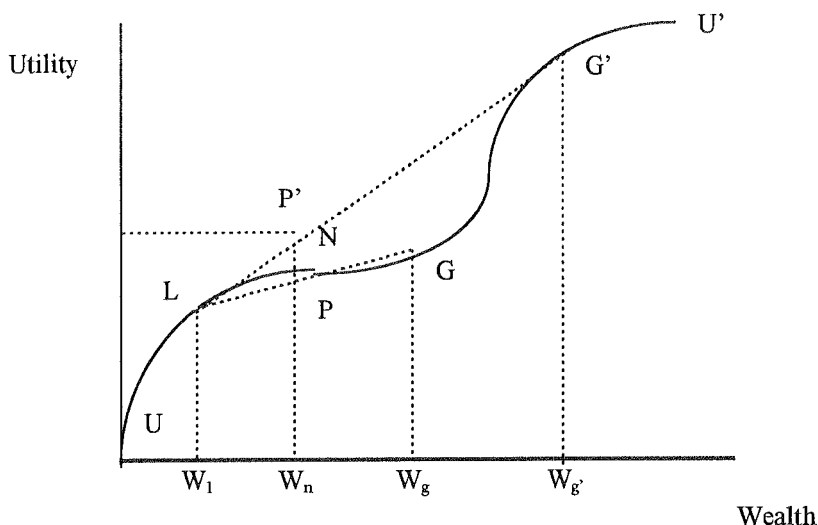
2.2.2 The Friedman-Savage Model

The second model is the Friedman-Savage model, named from a seminal 1948 paper, in which the authors described a utility function that has a shape allowing both risk-loving and risk-averse behaviour. The model uses an expected utility of wealth function with a concave central section allowing risk-loving behaviour to be consistent in that area, with a standard convex shaped utility function across low and high wealth ranges. The concave section of the expected utility of wealth function explains risk-loving behaviour such as gambling even when the prospect is unfair, in the sense that the expected payoff is less than the wager. Absolute wealth and relative wealth positions form the basis of the utility functions in the majority of the economic literature on the utility of gambling. Friedman-Savage model is based on a relative wealth structure across individuals, while the willingness of each individual to gamble is based on the relative wealth position of the individual.

Participation in the Friedman-Savage model is qualified by what the authors term the 'disaster zone'. A risky bet will not be accepted if, by losing, the gambler will enter an area of their wealth function which leads to disaster; ie. if this leads to a situation where financial commitments can no longer be honoured. Kwang's (1965) discontinuous utility function assists in explaining theoretically why this may occur.⁹ For example, if L in Figure 2.1 was below the weekly financial commitments of the gambler, then the bet would not be taken.

⁹ See pg. 15 for a further discussion of the Kwang (1965) analysis.

Figure 2.1 - The Friedman-Savage Utility Function



This utility function assumes that an individual's expected utility from any given bet is the probability of winning times the utility of his wealth if he wins, plus the probability of losing times the utility of his wealth if he loses.

Assume initial wealth is W_n . Two bets are examined. The first offers wealth L if the bettor loses and G if he wins. The weighted utility of these wealth positions lies on LG, at P, given the assumed odds. Since P is below N, the point on the utility function corresponding to the initial wealth, the individual will not accept the bet. The second bet offers wealth L associated with a loss and wealth G' for a win. The weighted utility of this bet, given the assumed odds, lies along LG', at P', which is above N, implying that the individual will accept this gamble.

In general terms, the Friedman-Savage model contends that an individual will choose to gamble when the expected utility of income from participating in the (potentially unfair)

game is greater than the utility derived from the present wealth level. Formally presented, an individual will gamble if and only if:

$$E(U) = PU(I_1) + (1 - P)U(I_2); \quad \text{where: } U \text{ is the utility of income;}$$

P is probability of a beneficial outcome;

I_1 is income after a favourable outcome;

and; I_2 is income after a negative outcome.

Brunk (1981) provides empirical support for this model. Based on survey answers to the question “Are you satisfied with your present income?”, results indicate that across the seven categories of satisfaction, those that were most dissatisfied spent an average of \$56.21 more per year on lotteries than the most satisfied.¹⁰ Further work on the Friedman-Savage model has been conducted by Markowitz (1952), Kwang (1965), Tversky (1967) and Pryor (1976). Markowitz illustrated that the UU' curve in the Friedman-Savage model gave a number of paradoxical results, and eliminated these by slight adjustments to the UU' curve¹¹. Kwang (1965) reinstated the traditional decreasing marginal utility of wealth assumption by making the function UU' discontinuous at the current wealth position. This was justified on the basis that this modification by arguing that gambling behaviour is defined by the indivisibility of the cost of purchasing a good.¹² Beneficial outcomes allow the bettor an opportunity to purchase goods that are otherwise outside the wealth range of the bettor, while a non-beneficial outcome will not shift the wealth position of the gambler to such an extent that the ‘disaster zone’ phenomena of the Friedman-Savage model operates.

¹⁰ This is a close proxy for the Friedman-Savage premise that dissatisfaction with income is the motivating factor behind people gaming.

¹¹ Markowitz (1952) argued that gambling is associated with a utility function derived from changes in wealth rather than absolute wealth levels and assumed a special shape for this function.

2.3 A Repetitive Gambling Model

Lee (1969) extended the Markowitz model by incorporating the possibility of repetitive playing. Gambling activity is undertaken due to the utility derived from a change in wealth, but this is determined by the outcome of previous wagers as well as the present result. The importance of this study is that it was the first to formally recognise that gaming, such as craps, poker machines, blackjack and keno, is conducive to repetitive play.

The repetitive gambling framework is based on the expected change in wealth per play:

$$P_1 \Delta W_1 + P_2 \Delta W_2 = \Delta W; \quad \text{where: } P_1 \text{ is probability of winning;}$$

P_2 is probability of losing;

ΔW_1 is change in wealth if win;

ΔW_2 is change in wealth if lose;

and; $P_1 + P_2 = 1$.

From the Friedman-Savage model, an individual will take the prospect¹³ if the expected utility of playing the game is greater than the expected utility if the game is not played, ie. the utility of the present wealth level:

$$U(P_1 \Delta W_1 + P_2 \Delta W_2) > U(0) = 0. \quad (2.1)$$

In a repeated game, the player will therefore take the prospect if his expected utility of the change in wealth per play of the game is greater than zero. However, since the expected change in wealth is known, should the prospect be taken, the expected utility

¹² For example, an average labourer would not be able to purchase a BMW (or any part of it) unless his wealth spectrum changes

of the change in wealth associated with playing a repeated game once is dependent upon the previous outcome. That is, the gain in wealth ΔW_1 or the loss ΔW_2 , resulting from the previous playing of the game, are directly related to the size of the gain or loss in the subsequent outcome of the gamble. The variance of ΔW resulting from playing the game once is also directly related to the previous outcome, since individuals update expected variance by the previous result.

Allowing X_i to be a random variable representing ΔW from the first trial;

$$\begin{aligned} Var(X_i) &= E(X_i)^2 - E(X_i)^2 \\ &= P_1 P_2 [\Delta W_2 - \Delta W_1]^2. \end{aligned} \quad \begin{array}{l} \text{For a derivation of the} \\ \text{variance see Appendix 2.} \end{array} \quad (2.2)$$

If the game is repeated n times, where each repeat is an independent trial with a stationary mean and variance, ΔW per play becomes:

$$\begin{aligned} &\frac{1}{n} \sum_{i=1}^n X_i \\ \Rightarrow \quad var\left(\frac{1}{n} \sum_{i=1}^n X_i\right) &= \frac{1}{n} P_1 P_2 [\Delta W_2 - \Delta W_1]^2 \end{aligned} \quad (2.3)$$

while the expected change in wealth remains:

$$E(X_i) = \overline{\Delta W}^{14} \quad (2.4)$$

Substituting these values into the expected utility equation yields:

$$P_1 U\left(\overline{\Delta W} - \frac{\overline{\Delta W} - \Delta W_2}{\sqrt{n}}\right) + P_2 U\left(\overline{\Delta W} - \frac{\overline{\Delta W} - \Delta W_1}{\sqrt{n}}\right) > U(0) = 0 \quad (2.5)$$

This inequality must be satisfied if the prospective gambler is to play the game.

¹³ In this chapter the terms “gamble” and “prospect” are used interchangeably. A technical distinction may be drawn between the two in that a gamble, by definition, involves a risk, whereas a prospect does not necessarily have such a characteristic. Hence a gamble may be called a “risky prospect.”

¹⁴ $E\left(\frac{1}{n} \sum_{i=1}^n X_i\right) = \frac{1}{n} n E(X_i) = E(X_i) = \overline{\Delta W}$

However, this model relies only on P and ΔW in order to come to this conclusion. Since Lee does not make an attempt to reject the psychological model the misperception of odds may therefore influence the number of gamblers who will play the game and the number of repetitions each gambler will undertake.

The criticism of the traditional models of the utility of gambling above and the subsequent research is that “Economists have resisted the idea of a utility of gambling¹⁵” in the sense of an intrinsic utility such as the “suspense and gamesmanship” of Samuelson (1952). By developing a model that does allow for a directly conferred utility of gambling to exist the apparent contradiction of a rational economic agent both insuring and gambling may be explained.

2.4 An Intrinsic or Directly Conferred Utility of Gambling Approach

Conlisk (1993) presented the “Tiny Utility of Gambling Model” which reconciles both risk-loving behaviour (gambling), and risk-averse behaviour (insuring) as observed to exist in rational economic agents. The model uses standard expected utility analysis for a risk-averse model but with a tiny utility of gambling term attached, that reflects the intrinsic utility to be derived from gambling. This additional term influences choice between two risky prospects, a risky prospect and a ‘sure thing’ and whether to take a risky prospect or not. The term influences choice since it adds a positively signed term to the usual expected return structure, making it more likely that a prospect will be accepted.

¹⁵ Conlisk (1993).

The model predicts that a variety of small gambles will be accepted by risk-averse economic agents but remains consistent with behaviour observed by individuals facing large risks. In contrast to Friedman and Savage (1948), Markowitz (1952), Kahneman and Tversky (1979, 1986, 1991) and Machina (1981, 1987) the Small Gamble Theorem developed by Conlisk allows for simultaneous gambling and insuring for any probability of winning and associated gain or loss, that is, for any risk-return structure of a gamble, providing an improvement upon the previous models which only allowed such a range of behaviour over severely restricted pay-off structures. Conlisk also supports the proposition of Markowitz (1952) and Lee (1961) that an individual's objective function is concerned with the potential change in wealth rather than absolute wealth positions.

2.4.1 Definitions

A fair bet is any gamble for which the expected return $pG + (1-p)L = 0$; a risky prospect is any gamble where the probability of an unsuccessful outcome, $(1-p)$, is greater than zero. That is, there is a positive probability of losing.

A fair prospect is any gamble which offers a fair bet structure as outlined above. Note: a fair prospect may be risky, although, unlike a gamble, a prospect is not constrained such that $(1-p) > 0$.

2.4.2 Fair Bet Structure

Assume a fair bet where G is the gain from a successful outcome and L is the loss from an unsuccessful outcome of a gamble¹⁶:

$$\therefore P(G) = p; \quad \text{and}; \quad P(L) = (1-p).$$

A fair bet for a risky prospect is: $pG - (1-p)L = 0$

$$\therefore L = pG/(1-p) \quad \Rightarrow \quad p = L/(L+G) \quad \text{or} \quad p = 1/[1+(G/L)] \quad (2.6)$$

This can be interpreted as a monotonic function of the gain-loss ratio and is therefore a measure of the skewness of the prospect, where G is the size of the prospect and p is the skewness. If an individual accepts the fair prospect (G,p) above then the preference value becomes an expected utility function modified to allow for the utility of gambling;

$$E(G,p,K) = pU[K+G] + (1-p)U[K-pG(1-p)^{-1}] + \varepsilon V(G,p); \quad (2.7)$$

where: K is initial wealth;

$U(W)$ denotes a utility of wealth function which displays the following characteristics;

$$U(0) = 0; \quad U'(W) > 0, \quad U''(W) < 0;$$

$$\text{and}; \quad U(W) < U_{\infty} < \infty;$$

Wealth = $K+G$ with probability p ;

$$= K-L = K-pG(1-p)^{-1} \text{ with probability } (1-p);$$

and; $\varepsilon V(G,p)$ is the intrinsic utility of gambling¹⁷.

\therefore A risky prospect (even a fair bet) will be accepted if and only if:

$$E(G,p,K) > E(0,0,K) = U(K). \quad (2.8)$$

¹⁶ For the purpose of the Fair Bet Structure it is irrelevant whether G and L are absolute values (as is usually the case with gambles) or are relative to initial wealth.

¹⁷ Note ε is an arbitrary weighting determined solely by individual preferences which scales the smallness of the utility derived from gambling but is constrained such that $\varepsilon > 0$.

$V(G,p)$ is the utility gained from the excitement and suspense the individual feels in the period between the acceptance of the prospect and the resolution of the uncertainty and ε is the utility of gambling independent of the potential gain and the probability of a successful outcome. Note that this is the utility derived from anticipating a successful outcome and associated improvement in the wealth position of the gambler, and is dependent on the risk-return structure of the prospect. ε is determined solely by individual tastes and it is the utility obtained directly from participation in the gambling activity, and is therefore independent of the expected pay-off.

Pollatsek and Tversky (1970) derived the standard deviation of a fair prospect, $\sigma(G,p)$, as representing the dispersion¹⁸ of the prospect. Conlisk (1993) extends this theory using the tiny utility of gambling term, $\varepsilon V(G,p)$, by specifying $V(G,p)$ to be a function of the standard deviation:

$$V(G,p)^{19} \equiv V'[\sigma(G,p)]; \quad (2.9)$$

where $\sigma(G,p)$ is a measure of gambling excitement.²⁰

Therefore, the standard deviation of a prospect may be written as:

$$\sigma(G,p) = G[p/(1-p)]^{0.5}; \quad (2.10)$$

and the expected absolute deviation may be written as;

$$\sigma(G,p) = pG = GL/(G+L).^{21} \quad (2.11)$$

¹⁸ The dispersion of the prospect is the range of possible returns from the gamble around the expected pay-off.

¹⁹ For any $0 < p < 1$ (ie. for a given G/L ratio) it is assumed that $V(G,p)$ as a function of G passes through the origin [$V(G,0) = 0$], is increasing in G [$V_1(G,p) > 0$] and is concave [$V_{11}(G,p) < 0$]. If $G > 0$ then $V(G,p)$ increases from zero proportionately with p and $\therefore V(G,0) = 0$ and $V_2(G,0) > 0 \forall G > 0$.

²⁰ $V'[\sigma(G,p)]$ is a concave and bounded function which converts the excitement of gambling, in the sense of Samuelson's "suspense and gamesmanship" into a utility function.

²¹ See Pollatsek and Tversky (1970) for a full derivation of these. Note that $G[p/(1-p)]^{0.5}$ and $GL/(G+L)$ are constant elasticities of substitution functions of G and L with $\eta = 0.5$ and 1 respectively. This implies that excitement isoquants in (G,L) space should look like standard production function isoquants, with a Cobb-Douglas excitement function:

This effectively allows Conlisk to avoid the misperception of odds criticism from this model; the implication is that the odds are not misperceived, rather, the individual receives greater pleasure per unit from anticipating the expected gain, pG , than displeasure per unit from anticipating the expected loss, $(1-p)L$. Therefore utility is discontinuous at the initial wealth point for each gamble, as in Kwang (1965).

Assigning arbitrary weights of $(1+\lambda)$ and -1 to the utility of anticipating winning and losing respectively yields, where $\lambda > 0$:

$$(1+\lambda)pG - (1-p)L = \lambda pG; \quad \text{where } \lambda pG \text{ is net pleasure.}^{22} \quad (2.12)$$

The change from p to $(1+\lambda)p$ improves the gamble expectation of a fair prospect from zero to $\lambda pG/(1-p)$, which implies that $\sigma(G,p) = pG/(1-p)$. Since this is not a true belief, the distortion of the gain probability will occur only in the $V(G,p)$ component of the tiny utility of gambling term in the utility function and not in the expected utility terms. This may explain why apparently risk-averse economic agents gamble.

2.5 The Fair Prospect Model.

From the utility function defined in the previous section, the Fair Prospect Model (FPM) can be derived:

$$E(G,p,K) \equiv pU[K+G] + (1-p)U[K-pG(1-p)^{-1}] + \varepsilon V(G,p); \quad (2.13)$$

$$\sigma(G,p) = G^\alpha L^{(1-\alpha)} = (GL)^{0.5} (G/L)^{(\alpha-0.5)} = G[p/(1-p)]^{(1-\alpha)}.$$

Therefore excitement may be increasing or decreasing in the skewness of the prospect, depending on the sign of $(\alpha-0.5)$. Luce (1980, 1981) discusses four measures of risk. The favoured approach is:

$$\sigma(G,p) = G^\theta p^\theta [A+B(1-p)^{1-\theta}].$$

²² Net pleasure from the gamble is greater than 0 because of the greater pleasure the gambler derives from anticipating a loss as opposed to the anticipated displeasure of losing.

where: $L = pG/(1-p) \leq K$ (no negative wealth).

The functions in U and V are assumed to be differentiable and obey the following conditions for any positive K , G and p :

$$\text{for } p < 1: \quad 0 = U(0) < U(K) < U_\infty < \infty,$$

$$U'(K) > 0, U''(K) < 0.$$

$$0 = V(0,p) = V(G,0) < V(G,p) < V_\infty < \infty,$$

$$V_1(G,p) > 0, V_{11}(G,p) < 0, V_2(G,0) > 0.$$

Hence, an individual will accept the risky prospect if and only if:

$$E(G,p,K) \geq U(K). \quad (2.14)$$

2.5.1 Treatment of the ‘Tiny Utility of Gambling Term’ in the FPM

There are two approaches to the treatment of the tiny utility of gambling term for any particular risky prospect. The first is to assume that the gambling term is present in gambles, such as wagering on a card game, but not present in non-gambles, such as purchasing insurance. The weakness of this approach is that classification of prospects as gambles or non-gambles may be arbitrary.

The second approach is to assume the gambling term is always present, but its effect may be overborne by the risk-averse expected utility terms.²³ Studies provide evidence that the size of the prospect determines the level of risk-aversion exhibited by

²³ For example, the gambling utility in terms of excitement and suspense is probably outweighed by the risk-aversion pressure from the two expected utility terms for most economic agents, when considering whether or not to insure, due to the size of the prospect; ie. G is large. An instance of this behaviour observed in practice is some car-owners taking out third party insurance for vehicles of low value as opposed to full comprehensive insurance, which is commonly purchased for expensive cars.

individuals²⁴, and the utility of gambling term dominates for relatively small prospects (no risk of negative wealth if the outcome is negative) but is overwhelmed by the expected utility terms when the stakes are large. The main advantage of this model is that the theorems provide testable implications without the need to categorise a prospect as either a gamble or non-gamble.

2.6 The Small Gamble Theorem

For any fair and risky prospect to be accepted under the FPM, the utility of gambling motive must be greater than the risk-aversion motive, otherwise risk-aversion implies rejection of any risky prospect.²⁵ Theory therefore requires the weight ε on the utility of gambling term to reach some threshold size²⁶ before any risky prospect would be accepted.

In contrast, the SGT states that any $\varepsilon > 0$ will be enough to make some prospects, as functions of (G, p) acceptable, dependent on the risk-return structure.²⁷ The justification of the SGT and ‘tiny’ utility of gambling term is that an individual’s utility of wealth function is approximately linear over a small region. This ‘local risk neutrality’ makes the risk-aversion motive second-order small, whereas the utility of gambling is first-order small.²⁸

²⁴ See Appendix 2 for this evidence.

²⁵ That is $\varepsilon V(G, p) > pU[K+G] + (1-p)U[K+G(1-p)^{-1}]$

²⁶ The threshold size is theoretically be determined by the risk-return structure (G, p) of the gamble. The size of the gamble, or potential loss, would be the crucial factor, due to the Friedman-Savage ‘disaster zone’.

²⁷ $E(G, p, K) = pU[K+G] + (1-p)U[K+G(1-p)^{-1}] + \varepsilon V(G, p)$ is always positive under the SGT for small prospects. This implies that $\varepsilon V(G, p) > pU[K+G] + (1-p)U[K+G(1-p)^{-1}]$ and hence the gamble will be accepted.

²⁸ See Appendix 2 for proofs of the Small Gamble Theorem and the associated conditions.

Formally, the net benefit, $b(G)$, from accepting a fair but risky prospect may be represented as:

$$b(G) \equiv E(G, p, K) - U(K); \quad \text{where } p \text{ is fixed.} \quad (2.15)$$

$$\Rightarrow b(0) = 0;$$

$$\Rightarrow b'(0) = \varepsilon V_{11}(0, p);$$

$$\Rightarrow b''(0) = p(1-p)^{-1} U''(K) + \varepsilon V_{11}(0, p);$$

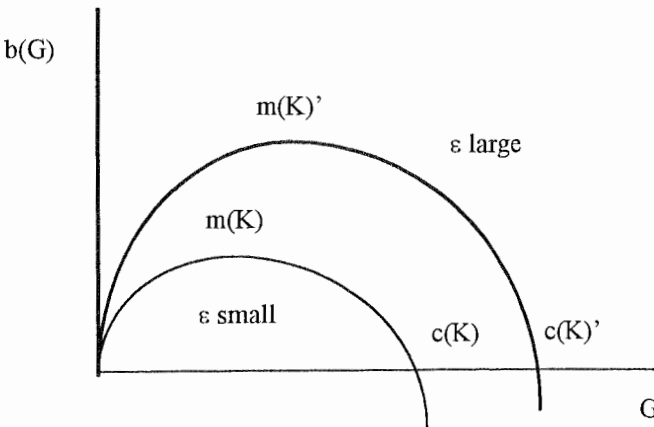
$$\Rightarrow b''(G) = pU''(K+G) + p^2(1-p)^{-1} U''[K-pG(1-p)^{-1}] + \varepsilon V_{11}(G, p). \quad (2.16)$$

All three right hand side terms of $b''(G)$ are negative and hence $b(G)$ is concave due to the concavity of both the utility of wealth function, $U(W)$, and the utility of gambling function, $V(G, p)$.²⁹

The SGT is concerned only with risky prospects of small size, ie. G is small. As G increases, the concavity effect will dominate. From (2.16):

$$b''(G) < 0 \quad \forall G; \quad (2.17)$$

Figure 2.2 - The Net Benefit of a Gamble Function



²⁹ The SGT rejects the usual association of concavity and risk rejection due to the weight of the utility of gambling term, ε , being a first order condition and concavity being a second-order condition.

and we expect $b(G)$ to rise into the first quadrant as in Figure 2.2, reach a maximum {at $m(K)$ } and then cross into the fourth quadrant {at $c(K)$ }, if ε is not too large. The subjective weighting ε determines the maximum point and the point of intersection between $b(G)$ and the horizontal axis. The more utility an individual derives from gambling, the higher will be the maximum, and the further along the G axis will the point of intersection.³⁰ This also implies that an individual with a higher subjective weight ε will accept ‘less fair’ prospects, ie. a prospect where the probability, p , is smaller for the same return, G .

For values of G greater than $c(K)$ the prospect is unacceptable; to the right of $m(K)$ the condition of concavity imposed by the expected utility terms in the FGT begins to dominate. This implies consistency between risk-averse behaviour for large prospects and gambling.

2.7 Extensions of the Small Gamble Theorem.

2.7.1 Multiple Prospects

The SGT can be extended to hold for multiple prospects. The individual simply selects the option with the largest expected utility, $E(G,p,K)$, or will remain at the status quo, $U(K)$. This analysis is valid for repeated gambling behaviour.

³⁰ See Appendix 2 for derivation of $m(K)$ and $c(K)$.

2.7.2 Multiple Outcomes

The SGT also holds for prospects with multiple outcomes such as a fair multiple outcome lottery, which can be represented by a vector of pay-offs, and associated probabilities:

$$X = [X_i]; \quad \text{and}; \quad P = [p_i];$$

such that;

$$\sum p_i X_i = 0; \quad \text{and}; \quad E(p, X, K) = \sum p_i U(K + X_i) + \epsilon V(X, p). \quad (2.18)$$

If the ratios among the pay-offs, X_i , are fixed and the probabilities, p_i , are fixed then the prospect will be accepted for small X_i ; following the SGT. This equation is outside the standard class of expected utility models because it is non-linear in p_i .³¹

2.7.3 The Lottery Theorem

Another extension is the Lottery Theorem (LT). A lottery offers a large potential gain, G , but since the probability of winning, p , is very small, the expected pay-off, pG , and hence the price of a lottery ticket is small relative to other forms of gambling. This smallness in the expected return suggests that the SGT applies to lotteries. Therefore, a negative shift in the bettor's wealth position will remain within the locally risk-neutral section of the individual's utility function. This suggests that the LT is plausible because it intuitively follows from the mathematical derivation that there exists a range of p -values, for which the prospect (G, p) to be accepted. If the individual has a strong taste

for skewness, an extreme lottery will not only be preferred to no gamble, but will be preferred to other gambles with smaller G -values.³²

2.7.4 The Unfair Prospect Model

Since all games with a set takeout rate are ‘unfair’ in that the expected return is less than the size of the gamble the extension that is the most relevant to gaming, is the Unfair Prospect Model (UPM). The UPM is essentially the same as the FPM but the acceptance function now becomes:

$$E(G,p,K) - U(K) > 0. \quad (2.19)$$

As long as the takeout rate is sufficiently small, or the weight ϵ on the gambling term in the expected utility function is large enough, the function will hold. Since the size of ϵ is determined entirely by individual preferences, there is no extension to the model which will be consistent across all individuals, but a simple extension is presented in Appendix 2.

2.8 Implications of the Small Gamble Theorem

By defining two different sources of directly conferred utility from the activity of gambling, one dependent upon the risk-return structure and so related to the excitement of anticipating a change in wealth, and the second defined solely by individual preferences, the SGT remains within standard neoclassical expected utility theory.

³¹ See Machina (1982, 1987) for a derivation of the condition and an explanation of non-linear framework. Machina defines a ‘local utility function’ whose second derivative defines acceptance or rejection. This restores the usual association of concavity and risk rejection.

³² See Appendix 2 for the proof of the Lottery Theorem.

Unlike previous theories, the SGT manages to reconcile the observed occurrence in rational economic agents of both risk-averse practices, such as insuring, and risk-loving behaviour such as gambling. By allowing the size of the gamble as well as the probability of success to influence the utility function $V[G,p]$ inferences may be drawn as to the characteristics of participants in various gambling activities.

The implication from the intrinsic utility of gambling function structure is that different combinations of p and G , which give the same expected return, will influence the subjective utility derived from a gamble, as well as the individual degree of risk-aversion. Hence the composition of the risk-return structure will have a causal influence on which gamblers play which game, even if the prospective bettor is in the locally risk-neutral section of the utility function. If the expected return is held constant, inferentially one could expect gamblers with a lower initial wealth position to be attracted to gambles composed of smaller probability of success, but which offer large gains. In contrast, wealthier gamblers could be expected to participate to a large extent in games which offer a higher probability of success, but with smaller gains to be made.

Intuitively this is logical: more wealthy gamblers would appear to have a relatively higher subjective weight, ε , while those with less initial wealth are influenced to gamble more by the anticipation of a significant positive shift in their wealth position and hence the majority of the intrinsic utility of gambling for these bettor's is derived from the $V[G,p]$ function. This postulate is the motivation for the empirical aspect of this paper. It is an a priori expectation that income will influence the type of gaming activity purchased.

This implication is supported by the figures in Table 2.1 below, which clearly shows the fall in lottery expenditure as income rises suggesting lotteries to be an inferior good. Hansen (1995) found a similar result for the Colorado state lottery in the United States.

Table 2.1 - Budget Share of Gaming by Type

Gaming Type				
Gaming as income share	Lotteries	Pokies	Casino-type	Equivalent income
Lower Quintile	0.012679	0.001305	0.00367	163.8935
Second Quintile	0.008224	0.00154	0.002923	316.2901
Central Quintile	0.006631	0.001288	0.001027	470.2021
Fourth Quintile	0.004998	0.000953	0.001343	739.9138
Upper Quintile	0.002489	0.000803	-0.00038	1447.336

Casino type games and poker machines do not have such a clearly defined income pattern, although the general trend for electronic gaming machines is similar to lotteries, except for the anomalous second quintile.

Chapter 3

3.1 Empirical Approaches to Gambling

The bulk of the existing empirical studies of gambling activity has been concerned with greyhound and horse racing. Literature focusing on gaming has generally studied lottery sales¹, although Worthington (1997) analyses all forms of legal gambling in Queensland and Borg et al (1991) study the incidence of casino-related gaming taxes. The approach often adopted in modeling the demand for gaming is to estimate either linear² or log-linear³ single equation OLS or Tobit demand functions.⁴ Single equation models of demand are not able to exploit the restrictions economic theory provide⁵, and in particular are unable to investigate the substitution between individual commodity demands. This paper is the first in Australia to use a systems approach in order to measure these effects in relation to gaming.

Since the 234.74% growth in real gaming expenditure in Australia over the period 1984-85 to 1993-94 has far outstripped growth in national income, it is important to determine which goods consumers are substituting away from in order to inject a higher share of their budget into gaming. This approach may also provide some insight into the relative regressivity of gaming taxes, by comparing the levels of taxes on the goods substituted on which consumers now spend less and gaming taxes.

¹ Eg. Hansen (1995), Scott and Garen (1994), Theil (1991), Kitchen and Powell (1991), Clotfelter and Cook (1989), Borg and Mason (1988) and Spiro (1981).

² Eg., Hansen (1995).

³ Borg, Mason and Shapiro (1991).

⁴ See Scott and Garen (1994) and Worthington (1997).

3.2 Data

The data used is pooled Household Expenditure Survey (HES) data from 1984 and 1993. This allows changes in consumption patterns over the period to be analysed.⁶ The 1984 survey consists of 4492 households, while the 1993 survey is based on 8389 households, in two levels of records. The first level describes demographic, expenditure and income information pertaining to each household. The second level details weekly expenditure on individual commodities. While the 1993 HES survey offers unit record data, household information is used in order to maintain consistency with 1984. The reference person for demographic information such as gender, employment status and country of birth is the household head.

The differing methods of categorising demographic variables in the two surveys posed some difficulties for consistency,⁷ but only marital status and occupation of the household head were so cross-categorised as to be unusable.⁸ Aggregating categories would not have been effective due to the inclusion of similar groups of workers in different categories in 1993 when compared with 1984. Gaming data is disaggregated into six net expenditure categories in the HES.⁹ Two categories have been aggregated in order to align the HES data with the minor gaming category defined by the Tasmanian Gaming Commission and CREA aggregate statistics. The demand system used for estimation includes three gaming budget shares as dependent variables. These

⁵ These restrictions are: (1) adding up ie. $\sum w_i = 1$; (2) homogeneity; (3) symmetry and; (4) negativity. These restrictions are further discussed in Chapter 4.

⁶ 1988 is not used due to the lack of a State identifier.

⁷ The definitions of all variables in the demand system are given in Appendix 3.

⁸ This is unfortunate since both variables have been identified as significant by Borg et al (1991).

⁹ See Appendix 3 for definition of each category of gaming.

groupings were determined by the risk-return structure of the types of gaming, as argued theoretically in Chapter 2 and the six HES categories were aggregated to three in line with the risk-return structure argument. The three categories are: (i) g_a which includes games with a low price, very low probability of winning and a large potential gain; (ii) g_b which is poker machines, offering an intermediate risk-return structure and are arguably the gaming type most suited to repetitive play; and (iii) g_c which includes casino-type games and such games as keno and bingo which have a higher probability of success but with smaller potential gains, for the same price as g_a .

The two main problems presented by the use of gaming data in estimation procedures is the presence of negative consumption expenditures (the presence of net winners¹⁰) and the presence of a large number of zero expenditures.¹¹

The large number of zero expenditures suggests that one possible approach is Tobit estimation. This process allows the grouping of the sample into non-participants (those with zero expenditure) and participants (those with non-zero, usually positive, expenditure). This approach assumes all zeros to be non-participants. This is justified in part by the extremely small probability of 'breaking even' when gaming, particularly in any sample week. Use of Tobit estimation accounts for both the influence of various explanatory variables on the decision, firstly, whether or not to purchase gaming products, and if the decision is to participate, then secondly, the subsequent decision regarding how much to spend.

¹⁰ The three categories had different percentages of net winners: $g_a = 2.958\%$, $g_b = 1.133\%$ and $g_c = 1.087\%$.

¹¹ The zeros cannot be distinguished into those that had no expenditure and those that 'broke even'. However, it should be noted that the probability of breaking even is very small.

Although the likelihood of zero expenditure on gaming indicating breaking even rather than non-participation is very small, the lack of an identifier suggests the approach followed in this paper, which is to remove the negative values as outliers and treat the zeros as actual zero expenditure rather than non-participation. Since participation in gaming is defined by a utility function which is in part determined by the anticipated utility of success,¹² it is sufficient that participants are aware that some gamblers will win, because the stake is placed *ex ante* rather than *ex post*.

3.3 Variables

A demand system motivated by the theoretical structure developed in Chapter 2 is tested using a number of socioeconomic and demographic variables that have been identified as significant in previous studies, or that the theoretical structure indicates may have a significant influence on gaming behaviour.¹³ Due to the exploratory nature of this paper, there is no unequivocal *a priori* rationale for predicting the direction and statistical significance of many of the regressors. Inclusion of these is justified on the grounds that results of the impact of household characteristics on gaming expenditure may be useful for policy makers and other interest groups.

Definitions of all the variables are available from the HES survey material. An explanation of how the variables have been structured in order to be used in the estimation procedure is contained in Appendix 3.

¹² See Section 2.4.1 for the definition of directly conferred gaming utility.

¹³ The influence of demographic variables may impact through the arbitrary ε term, the level of risk-aversion associated with each individual or through the relative income position of the individual or household.

3.4 The Model

A parametric demand system for gaming products and other household expenditures is developed. Existing studies in applied demand analysis commonly use the PIGLOG model or the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980). These models are rank 2, having budget share equations which are linear functions of the logarithm of income. Lewbel (1991) shows that US and UK household consumption data appears to be rank 3, meaning linear Engel curves derived from the rank 2 models lack sufficient flexibility to model the variety of shapes that Engel curves derived from household expenditure data, such as that used in this study, may encompass.¹⁴ Banks, Blundell and Lewbel (1993) derived a class of quadratic logarithmic preferences that provide integrable demand systems and which are data coherent. The rank 3 Quadratic Almost Ideal Demand System (QUAIDS) is a simple generalisation of the AIDS model, but which allows the flexibility of non-linear Engel curves while retaining integrability.

3.4.1 Derivation of the Model

Defining functions $\alpha(p)$, $b(p)$ and $\lambda(p)$ as specific functional forms of the first derivatives of a PIGLOG expenditure function with p being price of the good:¹⁵

$$\alpha(p) = \alpha_0 + \sum_s \alpha_s \log p_s + \sum_s \sum_r \gamma_{sr} \log p_s \log p_r / 2; \quad (3.1)$$

¹⁴ Deaton and Muellbauer (1980) do note that cross-section data often has non-linear Engel curves (at pg. 317) but do not develop a rank 3 model in order to take account of this.

¹⁵ The PIGLOG expenditure function is derived from a specific class of preferences which permit exact aggregation over consumers such that the representation of market demands is as if they were made by a rational representative agent. For a full discussion of this point see Muellbauer (1975, 1976).

$$\beta(p) = \sum_s \beta_s \log p_s; \text{ and;} \quad (3.2)$$

$$\log \lambda(p) = \sum_s \lambda_s \log p_s. \quad (3.3)$$

for some constants $\alpha_0, \alpha_s, \beta_s, \gamma_{rs}$ and $\lambda_s, \forall r$ and s .¹⁶

This implies the QUAIDS model has the indirect utility function for a utility maximising consumer:

$$\log I(p, x) = \left\{ \frac{b(p)}{\log \left[\frac{x}{a(p)} \right] - \lambda(p)} \right\}^{-1}; \text{ where } x \text{ is total expenditure.} \quad (3.4)$$

By Roy's Identity we can obtain the demand for each good, which take the form of quadratic budget shares:

$$w_s = \alpha_s + \sum_r \gamma_{sr} \log p_r + \beta_s \log \left[\frac{x}{a(p)} \right] + \frac{\lambda_s \left(\log \left[\frac{x}{a(p)} \right] \right)^2}{b(p)} \quad (3.5)$$

where: $w_s = \frac{y_s p_s}{x}$; which is the budget share of good s , where y is income; and

$$b(p) = \prod_i p_i s_i. \quad (3.6)$$

In order to maintain consistency with economic theory, the parameters should satisfy the restrictions for:

$$(a) \text{ homogeneity: } \sum_r \gamma_{sr} = 0 \quad \forall r; \quad (3.7)$$

$$(b) \text{ adding-up: } \sum_s \alpha_s = 1, \sum_s \gamma_{sr} = \sum_s \beta_s = \sum_s \lambda_s; \text{ and} \quad (3.8)$$

$$(c) \text{ symmetry: } \gamma_{sr} = \gamma_{rs} \quad \forall r, s. \quad (3.9)$$

¹⁶ See Lewbel (1995).

In practice, the adding-up restrictions are imposed by dropping a budget share equation from the demand system when estimating.

Since prices (the takeout rate) of the gaming products has been approximately constant over the two pooled samples, or present in only one sample, there is no intertemporal change, and so prices are assumed to be constant and equal to 1. Therefore, we write the QUAIDS model as:

$$w_s = \alpha_s + \beta_s \log[x] + \lambda_s (\log[x])^2. \quad (3.10)$$

3.5 Equivalence Scales

Data on household expenditure is “widely acknowledged to provide superior quality data and a rich source of information on household behaviour and welfare”¹⁷. However, when using household level data rather than personal unit record data, the impact on the behaviour of the household composition must be taken into account. This is particularly relevant when the heterogeneity of family and household structures in Australia is considered. The differing needs of adults and children influence the expenditure of the household, and this influence is captured in estimation by the use of an equivalence scale.

Equivalence scales offer a means to assess what expenditure different household compositions must have in order to achieve the same level of welfare as the reference household. The Engel and Rothbarth models are not derived directly from utility theory

¹⁷ Lancaster, Ray and Valenzuela (1997), pg 1.

and rely on stringent assumptions regarding the link between adult welfare and behaviour. The Engel (1895) model is derived from the theory that the welfare of households is inversely related to the household budget share of food. The Rothbarth (1943) scale is derived from the ratio of aggregate expenditures of demographically different households that maintain constant expenditure on defined 'adult goods'.

Barten (1964) introduced estimation of equivalence scales from systems of demand functions that satisfy the 'adding up' constraint. Blacklow (1997)¹⁸ estimated equivalence scales using the QUAIDS model for the data which is used in this analysis. Hence the Blacklow (1997) estimates of equivalence scales for Australian household expenditure data are used in the estimation, although an average across categories of the different age and sex categories of dependents in the household is used.

3.5.1 Equivalence Scale Model

The functional form of the model is the QUAIDS model with constant prices can be expanded to incorporate equivalence scales as follows:

$$w_s = \alpha_s + \beta_s \log \left[\frac{x}{m_0} \right] + \lambda_s \left(\log \left[\frac{x}{m_0} \right] \right)^2; \quad (3.11)$$

$$\text{where: } m_0 = \frac{(1 + \kappa K + \phi A)^\rho}{2A^\rho}; \quad K = \text{number of children in the household}; \quad (3.12)$$

and; A = number of adults in the household.

¹⁸ University of Tasmania Ph. D. dissertation, yet to be released. In contrast to the Engel and Rothbarth scales, accommodation expenses were included yielding a different result for the equivalence scale estimation which was found to be significant.

Following the Engel method, the scale is normalised at unity for a reference household, which is assumed to be a childless couple in this paper.

3.6 Estimation Issues

Demand systems are estimated using Maximum Likelihood Estimation (MLE). The adding up property of demand systems ensures that the sum of the disturbance terms over each equation within the system will equal zero for each time period. Denoting the vector of disturbance terms for each time period as v_t , it follows that the matrix of disturbance terms:

$$\Omega_t = E(v_t v_t'); \text{ is singular.} \quad (3.13)$$

Omitting the final element of v_t , and denoting the resulting sub-vector as \tilde{v}_t^n , and assuming \tilde{v}_t^n to be identically and independently distributed, permits the likelihood function to be written as:

$$L(\tilde{v}) = 2 \prod \left| \Omega_t \right|^{\frac{-1}{2}(n-1)} \exp\left(-\frac{1}{2} \sum_t (\tilde{v}_t^n)' \Omega_n^{-1} \tilde{v}_t^n\right).^{19} \quad (3.14)$$

Heteroskedasticity is tested for and corrected within ShazamE by using the HET command, which uses an information inverse matrix.

¹⁹ For a full explanation of the likelihood function see Barten (1969).

Chapter 4

4.1 Estimation

The first issue is whether the demand system being tested has quadratic Engel curves. This is determined by a likelihood ratio test based on the log-likelihood function value estimated for the linear and quadratic functions individually. The function is¹:

$$\lambda_{LR} = 2[L(H_1) - L(H_0)]; \quad (4.1)$$

where: $L(H_1)$ = log-likelihood value of quadratic system;

$L(H_0)$ = log-likelihood value of linear (restricted) system.

Given that the null hypothesis is true, λ_{LR} has an approximate chi-square distribution where the number of restrictions gives the degrees of freedom, J . If the function is statistically significant the null hypothesis of linearity is rejected.

The resulting λ term was significant for both the income and expenditure QUAIDS models, indicating that both functions had non-linear Engel curves.² This result is consistent with the previously mentioned results obtained using US and UK household expenditure data, and with the Jones and Mazzi (1996) application of the QUAIDS model to tobacco consumption and taxation in Italy. Estimation including the demographic characteristics is thus conducted using the quadratic expenditure model.

¹ See Griffiths, Hill and Judge (1993), pg. 455 for a further explanation of the test.

² The income system was used in order to obtain the income elasticities of the budget shares of the three gaming categories. The approach to estimating the system is explained in Section 4.4.

4.2 The Econometric Model

The expenditure demographic model tested may be written:

$$w_i = \alpha_i + \alpha_i r(\text{sex}) + \alpha_i s(\text{sur}) + \alpha_i t(\text{emp}) + \alpha_i u(\text{year}) + \alpha_i v(\text{cob}) \\ + \alpha_i w(\text{age}) + \beta_i [m - \alpha_0] + \psi_i [m - \alpha_0]^2; \quad (4.2)$$

where: m is the logarithm of equivalent expenditure; and

α_0 is a measure of subsistence expenditure³ $\forall i = 1, 7$.

One equation is the budget share of insurance which is a risk-averse expenditure as opposed to the risk-loving gaming budget shares.

Due to memory capacity problems the system was estimated iteratively, with each new demographic variable being included after the previous restricted system had converged. Piecewise regression can give biased results and so the likelihood ratio test was used in each instance to determine the joint significance or otherwise of the new variable. The results of the likelihood tests are given table A4.1 in Appendix 4.

4.3 Results of the Demographic Demand System

The results of estimation of equation 4.2 are contained in Table 4.1. Previous studies provide expectations regarding the direction of some of the regressors. For example, Scott and Garen (1994) and Clotfelter and Cook (1987) found that lottery ticket sales were positively related to unemployment levels. The results given in Table 4.1 indicate that this is not the case for any of the three gaming categories estimated. The negative

³ For a further explanation of the α_0 term see Deaton and Muellbauer (1980) or Lewbel (1995).

coefficients on the unemployment term in all three gaming equations indicate that net gaming expenditure, as a budget share, falls as the rate of unemployment rises.

Table 4.1 - Individual Determinants of the Demand for Gaming

Determinants of Household Gaming Expenditure

	Gaming - Type A	Gaming - Type B	Gaming - Type C
Variable			
subsistence expenditure	4.49900	4.49900	4.49900
std error	(0.46090)	(0.46090)	(0.46090)
t-ratio	9.762*	9.762*	9.762*
constant	0.0348370	0.0086088	-0.00260
std error	(0.00776)	(0.00475)	(0.00451)
t-ratio	4.485*	1.812*	-0.577
linear term	-0.0073424	-0.0024174	0.0016106
std error	(0.00228)	(0.00151)	(0.00144)
t-ratio	-3.211*	-1.609	1.118
quadratic term	0.0002996	0.0001942	-0.0001698
std error	(0.00019)	(0.00012)	(0.00012)
t-ratio	1.605	1.582	-1.448
sex	0.0030844	0.0001122	0.0006368
std error	(0.00039)	(0.00025)	(0.00024)
t-ratio	7.996*	0.442	2.630*
sur	-0.0257740	-0.0095162	-0.0078409
std error	(0.01616)	(0.01063)	(0.01013)
t-ratio	-1.595	-0.895	-0.774
employment	0.0005128	-0.0000603	0.0000987
std error	(0.00031)	(0.00021)	(0.00020)
t-ratio	1.645*	-0.294	0.503
year (1993)	0.0028272	0.0011492	0.0006251
std error	(0.00054)	(0.00036)	(0.00034)
t-ratio	5.269*	3.258*	1.858*
country of birth	0.0004490	-0.0001127	0.0002910
std error	(0.00039)	(0.00025)	(0.00024)
t-ratio	1.162	-0.444	1.200
age	0.0001112	0.0000170	0.0000265
std error	(0.0000114)	(0.0000075)	(0.0000072)
t-ratio	9.731*	2.267*	3.702*

Note: * indicates significance at the $\alpha = 0.05$ level of significance.

This result is supported by the positive coefficient of employment status for g_a and g_c , although this may capture a retirement effect. However, poker machines, g_b , indicate

expenditure increasing with a shift out of the labour force, although this is not statistically significant.

The coefficients of the constant, linear and quadratic terms for each gaming type suggest that lottery type games and poker machines have a bounded minimum budget share, while casino style games have a bounded maximum budget share. This could possibly be due to the habitual purchase of lottery tickets, compared to the more infrequent visits to a casino, or playing of similar style games.

Gaming expenditure as a budget share significantly increases with the age of the gambler, in all three categories of gaming, as found by Kitchen and Powells (1991) for Canada. This poses equity considerations for policy makers, since retired people and pensioners generally have a lower income than during their working life. Hence, gaming may be regressive across age as well as income categories. A method of testing this could be to include a quadratic age term, in an attempt to capture the income-age effect, similar to Scott and Garen (1994), or the use of a retirement dummy variable.

Male headed households have a higher net gaming expenditure than households with female heads. This is in line with the results found by Worthington (1997) and the North American literature.⁴ While this is significant for casino and lottery style games (g_a and g_b) the coefficient for poker machine expenditure is very small and statistically not significant. Individual level data may provide better results regarding the influence of gender on gaming behaviour.

⁴ For example, Clotfelter and Cook (1987) USA, and Kitchen and Powells (1991) Canada.

Although not individually significant, the null hypothesis of joint insignificance of ethnic background across gaming commodities is rejected. Migrants game less than do native born Australians, except on poker machines. This result agrees with the evidence found by Worthington (1997).

The proxy variable for accessibility, real per capita gaming expenditure, was tested independently and found to be statistically significant in all cases. The variable was tested independently due to memory capacity problems causing non-convergence.

The inclusion of the dummy variable for 1993 shows that the budget share of all three gaming categories has significantly grown over the period. The strongest growth is in lottery expenditure.

Table 4.2 - Budget Share Changes from 1984-1993

Effect of Year on Non-Gaming Budget Shares

Budget Share	Coefficient	Std. Error	t-ratio
Food	0.07401	0.0044	16.805*
Alcohol and Tobacco	0.00918	0.0023	3.986*
Entertainment	-0.01775	0.0106	-1.671*
Others	-0.08555	0.0117	-7.3074*
Insurance	0.00747	0.0016	4.6276*

Note: * signifies significance at the $\alpha = 0.05$ level of significance.

Table 4.2 indicates that this increase in expenditure comes from a substitution away from other entertainment and weekly household expenditure on 'other' goods, including consumer durables. The budget share of insurance has significantly grown over the same period, indicating further gaming expenditure is increasing among

participants, rather than a general fall in the average risk-aversion level of the sample, as is suggested by the percentage of participants in the sample falling as outlined in Chapter 1.

4.4 Regressivity of Australian Gaming Taxes

The absolute regressivity or progressivity of taxes on gaming can be determined using the income elasticity of the income share of gaming. The closer to zero is the income elasticity of the budget share of a product, the higher is the degree of necessity. Hence, taxes on such products will be more regressive. From the quadratic income model⁵, the income share of a gaming product may be defined as:

$$g_i/i = \alpha_i + \beta_i \log i + \psi_i [\log i]^2; \quad (4.3)$$

$$\Rightarrow g_i = i\alpha_i + i\beta_i \log i + i\psi_i [\log i]^2;$$

$$\Rightarrow \frac{\delta g_i}{\delta i} = \alpha_i + \beta_i \log i + \beta_i + \psi_i [\log i]^2 + \psi_i 2 \log i;$$

$$\text{which, since } g_i/i = \alpha_i + \beta_i \log i + \psi_i [\log i]^2;$$

$$\Rightarrow \frac{\delta g_i}{\delta i} = g_i/i + \beta_i + 2\psi_i \log i;$$

$$\Rightarrow \xi g_i = \frac{\delta g_i}{\delta i} \left[\frac{i}{g_i} \right]; \text{ elasticity of budget share of gaming;}$$

$$\Rightarrow \xi g_i = 1 + [\beta_i + 2\psi_i \log i] \left[\frac{i}{g_i} \right]. \quad (4.4)$$

⁵ The income system was estimated using an equivalence scale derived from estimating the income-weighted savings gap (ie. equivalent total household income minus expenditure, which is defined as the sum of household expenditures forming the dependent variables in the expenditure system). This, in effect, assumes that the income equivalence scale used is a weighted function of the expenditure equivalence scale estimated by Blacklow (1997).

Using this measure: if $\xi g_i < 0$ then the good is inferior;

if $0 < \xi g_i < 1$ then the good is a necessity, and a tax will be regressive;

if $\xi g_i > 1$ then the good is a luxury, and a tax will be progressive.

Results of the elasticities of the income share of the three categories of gaming products analysed may be seen in Table 4.3 below. The monotonically decreasing budget share of g_a and g_b suggest regressivity and this is confirmed by the estimated income elasticity of the budget share of gaming. From Table 4.3 it can be seen that income elasticity increases with income quintile for g_a and g_b . For more detail on income quintile and expenditure on gaming products see table A4.2 in Appendix 4.

Table 4.3 - Income Elasticity of Gaming Type by Income Quintile

	Quintile average equivalent income	Income elasticity of g_a	Income elasticity of g_b	Income elasticity of g_c
Lower quintile	16399.577	0.058899	0.230854	0.196091
Second quintile	31633.367	0.113415	0.32036	0.309945
Central quintile	47028.292	0.161808	0.577845	1.190328
Fourth quintile	73997.436	0.24111	0.853938	0.899933
Upper quintile	144733.578	0.490406	1.496368	-3.453929

The results of estimating the income elasticities of each type of gaming indicate that taxes on lottery products are regressive across all income categories, while poker machines taxes are regressive in all but the highest income quintile. Taxes on casino and casino type games are regressive in all but the central income quintile, but this result must be challenged due to the net negative expenditure (net winnings) of gamblers in the uppermost income quintile.

These results accord very well with the theoretical model of gaming behaviour developed in Chapter 2. Excise taxes on gaming products have the potential to be particularly regressive for lower socio-economic groups, similar to those on tobacco and alcohol, which, along with gambling, are classed as 'sin goods'.⁶

⁶ For tobacco tax regressivity in Italy see Jones and Mazzi (1996). See Jones (1989) for an analysis of the demand for alcohol and tobacco using maximum likelihood estimation.

Chapter 5

5.1 Summary of Results

The results presented in Chapter 4 suggest that State governments should be aware of the regressive nature of most gaming products. The type of expansion of the industry that is currently occurring, such as metropolitan casinos and suburban poker machine and keno facilities, appear to present a possible strongly negative welfare effect. Demographic variables such as age, gender, and employment status have significant effects on gaming expenditure. This presents an opportunity for State governments to target further gaming facilities at those groups least subject to the regressive nature of gaming taxation.

5.2 Limitations and Further Research

This research contains some limitations which are worth discussing. Firstly, gaming is a growth industry in Australia in the 1990's, but due to the lack of availability of current data, this trend is not fully captured in the estimation process. In particular, the opening of three casinos in Queensland as well as the Sydney Harbour Casino and Crown Casino in Melbourne could influence the results markedly. New data would also allow for the use of an individual category of casino gaming expenditure, and this suggested as one area where further research could be undertaken.

A further limitation of the data was the lack of prices for gaming, allowing no price variation effects. If a price measure could be constructed for the different forms of gaming, as is done by Walker et al (1996), a Social Welfare Function could be constructed¹ which would give a better understanding of the welfare effects of gaming taxes and changes in the tax rates. This research offers the general statement that gaming taxes are regressive, but without comparison with the regressivity of taxes on other commodities, the tax system is not evaluated as becoming more or less regressive with the expansion in gaming facilities.

The inclusion of different demographic variables is another means to extend the research in this field. Education levels and occupation may offer a further insight into what influences people to participate in gaming, and a more robust measure of accessibility could be constructed. Accessibility is a key criteria to gaming behaviour, and some formal measure of the relative ease of access to different gaming facilities could enhance not only the empirical aspect of gaming research, but the theoretical structure. The use of real per capita gaming expenditure as a proxy for accessibility does not accurately capture the influence of easy access to gaming facilities on the budget share of gaming expenditure, especially given the marked difference in the availability of gaming products between urban and rural centres.

The treatment of zeros in the data set as zero expenditure rather than non-participation offers a chance to extend demand system analysis of gaming in Australia using the Tobit approach of Worthington (1997) and Scott and Garen (1994). Distinguishing

¹ Similar to that used in Jones and Mazzi (1996).

between non-participants and those who ‘broke even’ offers a method of including the net winners in the estimation, as well as a determination of whether the change in gaming expenditure resulting from increased expenditure by participants or an increase in participation rates.

5.3 Conclusion

The exploratory nature of this paper placed many potential improvements to the work outside the scope of this research. Additional data and computing power limitations restricted the number and degree of sophistication of the demographic variables used. The next HES survey and the use of more advanced computing facilities offer the chance to extend the current research into gaming behaviour and the regressive, or otherwise, nature of gaming taxes in Australia.

It is hoped that State governments will take some note of the potential widening of the income gap that may occur if heavy reliance on gaming receipts as State own-source revenue continue. In addition it is hoped that the results presented in this analysis may provide useful policy guidelines when further expansions of the Australian gaming industry are planned.

Appendix 1

The Popularity of Gaming Activities in Australia

Table A1.1 - Gaming Participation Rates by Year

Gaming Participation Rates (%)

	g1	g2	g3	g4	g5	gtotal
1984	11.82	47.46	6.77	0.267	28.76	61.15
1993	8.62	43.28	8.55	0.871	21.44	55.97

- g1 = Lottery tickets + soccer pools.
 g2 = Lotto (inc. Tattsлото) + instant lotteries eg. scratch and win.
 g3 = Poker machines and other electronic gaming machines.
 g4 = Casino gaming (in Tasmania this includes poker machines).
 g5 = Minor gaming such as bingo, keno etc.

Comparison of Racing and Gaming Activity in Australia

Table A1.2 - Racing Turnover by Year

Total Real Racing Turnover \$m

Year	NSW	Victoria	Qld	SA	WA	Tasmania	ACT	NT
1984-85	5045.486	3370.255	1862.596	845.532	911.28	222.213	130.059	105.093
1985-86	5308.143	3549.399	1935.736	839.981	856.311	228.374	154.427	80.949
1986-87	530.074	3498.574	1762.896	732.522	807.953	213.957	151.323	81.841
1987-88	5358.535	3545.007	1770.794	766.16	846.253	229.532	156.601	80.443
1988-89	5778.198	3519.967	1850.373	793.536	868.945	235.287	150.845	76.604
1989-90	5693.939	3423.423	1838.717	814.397	864.149	250.664	152.584	81.581
1990-91	5566.34	3257.668	1801.92	786.436	770.641	245.919	146.625	93.778
1991-92	5306.153	3198.982	1786.355	738.558	707.734	255.753	136.978	90.32
1992-93	5006.553	3164.08	1822.882	725.899	769.043	269.037	136.472	106.165
1993-94	4870.44	3167.403	1898.584	790.949	860.57	282.297	135.371	132.675

Table A1.3 - Gaming Turnover by Year

Total Real Gaming Turnover \$m

Year	NSW	Victoria	Qld	SA	WA	Tasmania	ACT	NT
1984-85	10517.96	1076.928	455.854	273.305	189.96	311.339	372.762	176.108
1985-86	10275.66	997.000	745.785	502.186	421.278	301.467	376.791	193.997
1986-87	10538.06	1021.564	985.409	662.618	720.946	283.658	357.709	276.207
1987-88	10882.88	1064.463	1188.622	710.429	773.241	311.674	440.297	275.449
1988-89	12770.67	1039.929	1334.321	890.961	1021.519	339.355	542.665	419.79
1989-90	13912.92	1150.114	1442.884	1020.192	1226.963	335.982	589.03	824.452
1990-91	14192.11	1230.450	1713.234	854.228	1409.696	340.906	623.868	405.881
1991-92	15061.87	4081.315	2039.04	888.754	1456.238	359.066	726.929	424.156
1992-93	16449.35	1484.103	3612.435	888.436	1747.207	357.297	823.501	347.67
1993-94	21436.7	8823.537	4523.197	885.255	2182.93	962.737	1056.635	376.755

Appendix 2

Derivation of the Variance of X_i

$$\begin{aligned}
 Var(X_i) &= E(X_i)^2 - E(X_i)^2 \\
 &= P_2\Delta W_2^2 + P_1\Delta W_1^2 - [P_2\Delta W_2 + P_1\Delta W_1]^2 \\
 &= P_2\Delta W_2^2 + P_1\Delta W_1^2 - [P_2^2\Delta W_2^2 + P_1^2\Delta W_1^2 + 2P_1P_2\Delta W_2\Delta W_1] \\
 &= P_2\Delta W_2^2 - P_2^2\Delta W_2^2 - 2P_1P_2\Delta W_2\Delta W_1 + P_1\Delta W_1^2 - P_1^2\Delta W_1^2 \\
 &= P_2\Delta W_2^2(1-P_1) - 2P_1P_2\Delta W_2\Delta W_1 + P_1\Delta W_1^2(1-P_2) \\
 &= P_1P_2[\Delta W_2 - \Delta W_1]^2
 \end{aligned}$$

Evidence From Psychological Trials

Studies indicate that the percentage of risk-aversion (%RA) increases with the size of the prospect G . G -values are in dollars throughout.

Hershey, Kunreuther and Shoemaker (1982) found that for a sample of subjects, and

for $p = 0.5$

For $G = 200$, %RA = 58; ($n = 66$)
For $G = 1,000$, %RA = 77; ($n = 69$)
For $G = 2,000$, %RA = 86; ($n = 72$)
For $G = 10,000$, %RA = 95; ($n = 74$);

for $p = 0.1$

For $G = 100$, %RA = 23; ($n = 82$)
For $G = 200$, %RA = 47; ($n = 201$)
For $G = 10,000$, %RA = 70; ($n = 82$); and

for $p = 0.01$

For $G = 100$, %RA = 16; ($n = 82$)

For $G = 1,000$, %RA = 35; ($n = 82$)

For $G = 10,000$, %RA = 60; ($n = 82$)

For $G = 100,000$, %RA = 70; ($n = 82$)

For $G = 1,000,000$, %RA = 81; ($n = 82$).

Battalio, Kagen and Komain (1990) report supporting results over a sample of 35, and

for $p = 0.5$:

For $G = 10$, %RA = 40,

For $G = 20$, %RA = 57.

Proof of the Small Gamble Theorem.

Assume the Fair Prospect Model (FPM) holds for any given $P(G) = p$.

Assume p (skewness of the prospect) fixed, and that G (size of the gamble) varies.

If ε is small, the individual will accept small prospects and reject large prospects.

Consider prospect (G, p) for any $0 < p < 1$:

$$\text{If } \varepsilon \leq [U(K) - pU(K/p)] / V[K(1-p)/p]; \quad (1)$$

then three statements hold:

1) \exists some critical positive value of G , $c(K)$, dependent on K , such that

$$E(G, p, K) > U(K) \text{ iff } 0 < G < c(K);$$

2) \exists some uniquely preferred positive prospect size, $m(K)$, within the set of acceptable prospects, such that $0 < m(K) < c(K)$ and such that $G = m(K)$ uniquely maximises $E(G, p, K)$ with respect to G ; and

3) If the utility of wealth function $U(W)$ exhibits declining risk-aversion, then the range of acceptable prospects and the size of the uniquely preferred prospect increase with initial wealth, K :

Formally: If $U''' > 0$, then $A'(K)$ and $B'(K) > 0$.

Proof of Statements (1) and (2):

Define bet benefit of a gamble of size, G , and initial wealth position, K , as:

$$b(G, K) \equiv E(G, p, K) - U(K)$$

$$\therefore b(G, K) = pU(K+G) + (1-p)U[K-pG(1-p)^{-1}] + \varepsilon V(G, p) - U(K)$$

We can obtain the following first order conditions:

$$\therefore b_1(G, K) = pU'(K+G) - pU'[K-pG(1-p)^{-1}] + \varepsilon V_1(G, p); \quad \text{w.r.t. } G$$

$$\therefore b_2(G, K) = pU'(K+G) + (1-p)U'[K-pG(1-p)^{-1}] - U'(K); \quad \text{w.r.t. } K$$

and we can obtain the following second-order conditions:

$$\therefore b_{11}(G, K) = pU''(K+G) + p^2(1-p)^{-1}U''[K-pG(1-p)^{-1}] + \varepsilon V_{11}(G, p)$$

$$\therefore b_{12}(G, K) = pU''(K+G) - pU''[K-pG(1-p)^{-1}].$$

From these conditions and the assumptions of the FPM we can infer:

$$b(0, K) = 0; \quad (a)$$

$$b_1(0, K) = \varepsilon_1 V(0, p); \quad (b)$$

$$b_{11}(G, K) < 0; \text{ and} \quad (c)$$

$$b[K(1-p)/p, K] = (\varepsilon - \varepsilon^*)V[K(1-p)/p, p]; \quad (d)$$

where $\varepsilon^* = \text{RHS of (1)}$.

From above (a) shows that $b(G, K)$ passes through the origin; (b) shows that the direction is into the first quadrant; (c) shows that there will be some unique maximum of $b(G, K)$ w.r.t. G within the range of acceptable prospects iff in (d) $\varepsilon^* > \varepsilon$, as in the graph in section 2.2.3.

Proof of Statement (3):

Recall $U''' > 0$ and the assumptions of the FPM in order to obtain:

$$b_1[c(K), K] < 0; \quad (e)$$

$$b_{12}[G, K] = b_{21}[G, K] > 0; \quad (f)$$

$$b_2(0, K) = 0; \text{ and} \quad (g)$$

$$b_2(G, K) > 0; \quad \forall G. \quad (h)$$

The $b(G)$ -maximising value $m(K)$ is implicitly defined by the first-order condition:

$$b_1[m(K), K] = 0; \text{ and}$$

the intercept value $c(K)$ is implicitly defined by:

$$b[c(K), K] = 0.$$

Implicit differentiation of these yield the following first-order conditions:

$$m'(K) = -b_{12}[m(K), K]/b_{11}[m(K), K]; \text{ and}$$

$$c'(K) = -b_2[c(K), K]/b_1[c(K), K]; \text{ and}$$

(c), (e), (f) and (h) show that both derivatives are positive.

Proof of the Lottery Theorem.

Assume FPM:

If ε is not too small, then for any G , an individual will accept a prospect if p is small enough.

Formally:

$$\varepsilon > GU'(K)/V_2(G,0); \quad \forall G > 0;$$

then, $\forall G > 0$, \exists a positive constant D , such that $E(G,pK) > U(K) \quad \forall 0 < p < D$.

Defining the net benefit of the prospect as:

$$b(p) \equiv E(G,p,K) - U(K); \quad \text{which is now a function of } p;$$

$$b(p) = pU(K+G) + (1-p)U[K-pG(1-p)-1] + eV(G,p) - U(K);$$

$$\therefore b'(p) = U(K+G) - U[K-pG(1-p)-1] - G(1-p)-1U'[K-pG(1-p)-1] + eV_2(G,p);$$

$$\therefore \text{at } p = 0 \text{ and } V(G,0) = 0; \quad b(0) = 0; \text{ and}$$

$$b'(0) = U(K+G) - U(K) - GU'(K) + \varepsilon V_2(G,0);$$

$$> -GU'(K) + \varepsilon V_2(G,0)$$

$$= V_2(G,0)[\varepsilon - GU'(K)/V_2(G,0)].$$

Proof of the Unfair Prospect Model.

The expected utility function is defined as in the FPM. An individual will prefer a risky prospect (G,L,p) to a corresponding sure payment $s \equiv pG - (1-p)L$:

$$\text{iff: } E(G-S,p,K+S) > U(K+S).$$

Specialising to the instance where $L = 0 \Rightarrow S = pG$ and defining the net benefit of the unfair prospect over the sure payment as:

$$b(G) \equiv E(G-S,p,K+S) - U(K+S);$$

$$b(G) \equiv pU(K+G) + (1-p)U(K) + \varepsilon V[(1-p)G,p] - U(K+pG).$$

The object is to show that this model has the same shape as the FPM, for some constant C , which will make the risky prospect preferable to the sure payment iff $0 < G < C$.

In order to prove this, assume:

$$\varepsilon < (1-p)[U_\infty - U(K)]/V_\infty; \text{ and}$$

$$b(G) = 0 \text{ has at most one positive solution for } G.$$

From these assumptions we attain:

$$b(0) = 0, b'(0) = \varepsilon(1-p)V_I(0,p) > 0; \text{ and}$$

$$b(\infty) = \varepsilon V(\infty,p) - (1-p)[U_\infty - U(K)] < 0.$$

And thus, the UPM has the same shape as the FPM as illustrated in section 2.2.3.

Appendix 3

Dependent Variables

Dependent variables are a (8x1) vector of household expenditures on certain goods in the sample week expressed as budget shares:

ga	=	Lottery tickets + soccer pools + Lotto (inc. Tattslotto) + instant lotteries eg. scratch and win.
gb	=	Poker machines and other electronic gaming machines.
gc	=	Casino gaming (in Tasmania this includes poker machines) + Minor gaming such as bingo, keno etc.
food	=	Food + non-alcoholic beverages.
alctob	=	Alcohol + tobacco.
ent	=	Entertainment and recreation - (ga + gb + gc).
other	=	all other household weekly expenditure. (Default variable).
ins	=	Household expenditure on insurance: included separately due to risk-averse nature of insurance as opposed to risk-loving nature of gaming.

Independent Variables

Independent variables form a (1x10) vector of socioeconomic and demographic characteristics of the households in the survey week:

sex*	=	Gender of the household head - 0 for female, 1 for male.
sur**	=	State unemployment rate, used as a proxy for the general level of aggregate economic activity in each State.

$rpcg_i^{**}$	=	Real per capita gaming expenditure for each State: included as a proxy for relative accessibility of each type of gaming.
eqs	=	Equivalence scale determined from the family composition of the household and number of dependents in the household.
age	=	Age of the household head - continuous variable composed of the class-mark of 5 year age categories above 20.
cob^*	=	Country of birth of the household head - 0 for Australia and other oceania, 1 for others (migrants). Note New Zealanders are not classified as migrants due to legal status in Australia.
emp^*	=	Employment status of the household head - 0 for unemployed or not in the labour force, 1 for wage and salary earners (part and full time) and self-employed.
$year^*$	=	Indicates year of sample - 0 for 1984, 1 for 1993.
α_0	=	Coefficient indicating the level of subsistence expenditure.
α_i	=	Constant term in each budget share equation.
β_i	=	Linear term of equivalent expenditure in each budget share equation.
z_i	=	Quadratic term of equivalent expenditure in each budget share equation.

Note: * indicates a categorical variable which is proxied by dummy variables for each category.

** indicates a proxy variable for a difficult to measure factor.

Unemployment

State unemployment rates were obtained from the ABS State Yearbooks. Since these figures were not available for Northern Territory and the Australian Capital Territory they were assigned the national average for the year.

Table A3.1 - State Unemployment Rate (5) By Year

State Unemployment Rate (%)

	NSW	Vic	Qld	SA	WA	Tas	NT	ACT
1984	8.9	7	9.2	10.8	8.9	10.5	8.9	8.9
1993	10.4	12.4	10.3	11.7	9.7	12.3	10.8	10.8

Real per Capita Gaming Expenditure

Real per capita gaming expenditure statistics were obtained from the Tasmanian Gaming Commission and CREA Gambling Statistics 1972-73 to 1995-96 and since these were in 1995 \$A they were deflated using the CPI Indicator provided to 1988 \$A in order to match the HES data.

Table A3.2 - Real State per Capita Gaming Expenditure

Real Per Capita Gaming Expenditure By State and Type

		NSW	Vic	Qld	SA	WA	Tas	NT	ACT
1	1984	10.59	3	18.12	5.65	9.38	7.32	6.45	4.45
	1993	9.89	1.81	2.92	0.81	1.44	1.65	6.22	4.4
2	1984	56.34	89.48	66.78	45.19	53.66	68.73	47.88	55.72
	1993	47.66	74.12	79.5	57.24	107.53	64.99	70.9	50.97
3	1984	247.87	0	0	0	0	0*	0	192.86
	1993	362.5	170.17	121.05	0	0	0*	25.48	373.36
4	1984	0	0	0	0	0	102.69	173.89	0
	1993	0	0	82.33	87.97	239.75	133.48	244.37	129.67
5	1984	0	24.94	0	45.75	0	30.82	7.5	N/A
	1993	11.6	29.27	35.97**	48.77	15.79	21.98	N/A	N/A

* included in casino expenditure since all poker machines were in casino until 1996.

** indicates one figure included in this category is not available.

N/A means figures not available. Assigned an expenditure value of zero in the data.

Note: zero indicates no access to type of gaming in State.

Appendix 4

The demand system was estimated iteratively, with new variables being included after the previous restricted system had converged. In order to determine the joint significance of the coefficients of the newly included variable the log-likelihood values were used at each stage to conduct a likelihood ratio test as explained in Section 4.1.

Table A4.1 shows that each included variable proved to be jointly significant.

Table A4.1 - Test of Joint Significance of Variables Results

Likelihood Ratio Test of Significance Results

	Log-likelihood Value	Test Value
Variable		
Linear (β)	3519.5	
Quadratic (z)	3549.7	60.4
Gender*	137645.8	268192.2
State Unemployment Rate	138811.7	2331.8
Employment Status*	139397.6	1171.8
Year*	139550.3	305.4
Country of Birth*	139598.9	97.2
Age*	139871.5	545.2

Note: * signifies a dummy variable.

Income Elasticities of the Budget Share of Gaming

The income elasticity of the budget share of gaming products is used as a measure of the regressivity of gaming taxes. Table A4.2 below shows these elasticities.

Table A4.2 - Income Elasticities of Gaming Product by Income Quintile

	Participant's average expenditure on g_a	Income share of g_a	Income elasticity of g_a	Quintile average equivalent income
Lower quintile	486.2079927	0.02964759	0.0588991018	16399.57661
Second quintile	553.5189769	0.01749795	0.1134149163	31633.36694
Central quintile	618.6831149	0.01315555	0.1618078363	47028.29223
Fourth quintile	703.9054653	0.00951257	0.2411098499	73997.43561
Upper quintile	748.9628733	0.00517477	0.4904057487	144733.5784
	Participant's average expenditure on g_b	Income share of g_b	Income elasticity of g_b	Quintile average equivalent income
Lower quintile	505.5137615	0.03082481	0.230853708	16399.57661
Second quintile	794.1202532	0.02510388	0.320359721	31633.36694
Central quintile	699.4753363	0.0148735	0.577844923	47028.29223
Fourth quintile	800.1277533	0.01081291	0.853937395	73997.43561
Upper quintile	984.7631579	0.00680397	1.496367547	144733.5784
	Participant's average expenditure on g_c	Income share of g_c	Income elasticity of g_c	Quintile average equivalent income
Lower quintile	298.6543689	0.0182111	0.196091041	16399.57661
Second quintile	414.0294118	0.01308838	0.309944579	31633.36694
Central quintile	171.6041379	0.00364896	1.190327772	47028.29223
Fourth quintile	385.112782	0.00520441	0.899933118	73997.43561
Upper quintile	-216.981763	-0.0014992	-3.453929424*	144733.5784

Note: * indicates a spurious result which should be given little credence due to an average negative net expenditure on g_c for the wealthiest quintile. That is, this quintile are net winners when playing casino type games.

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